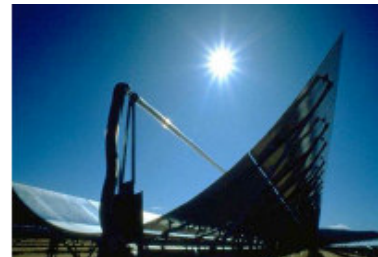


# Renewable energies

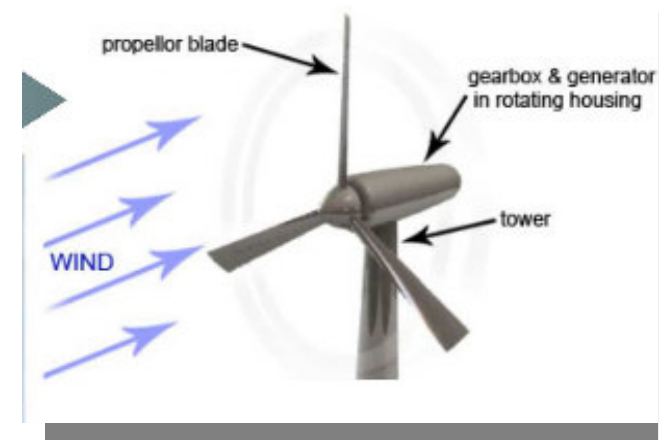
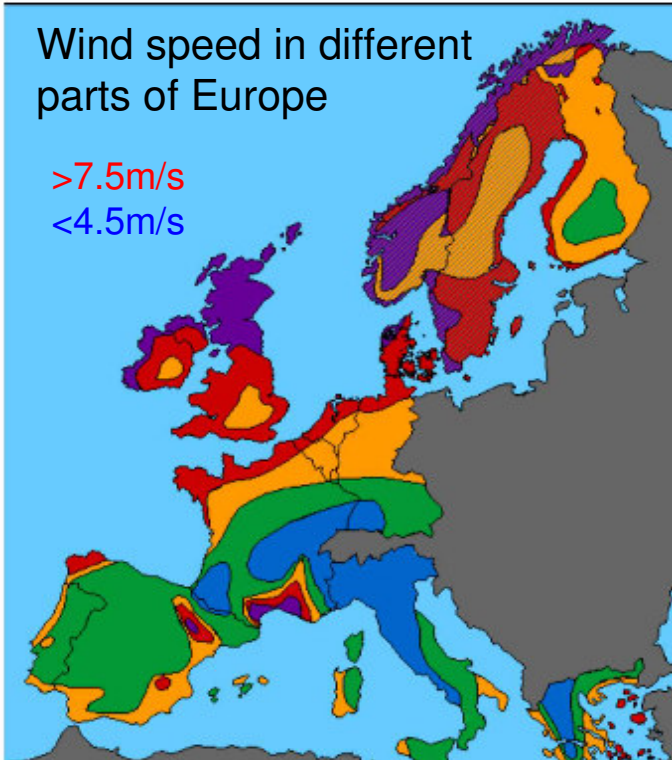
## Wind and solar power resource evaluation

*8 July 2010*

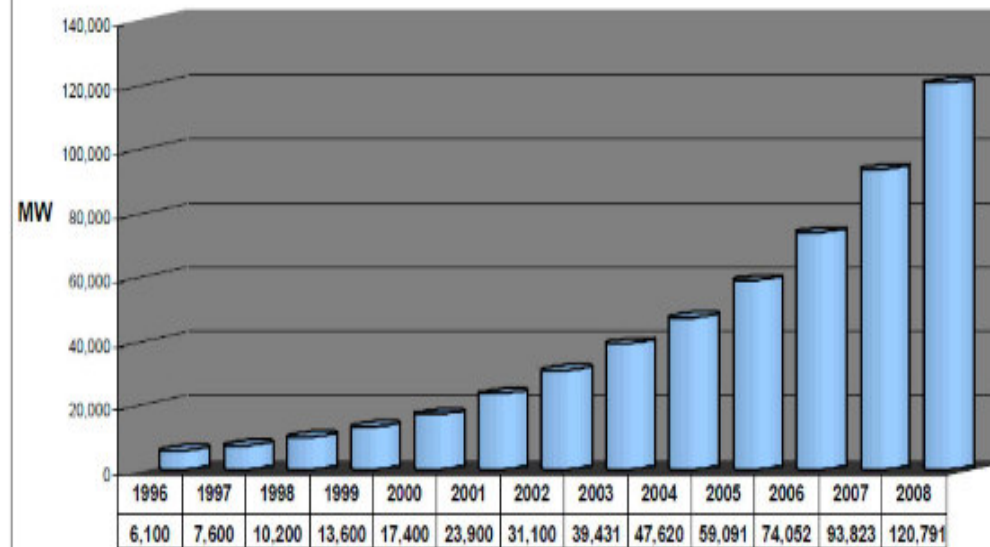


Wind speed in different parts of Europe

>7.5m/s  
<4.5m/s

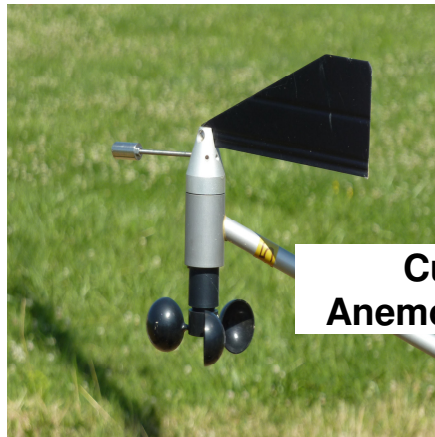


Global cumulative installed capacity 1996-2008

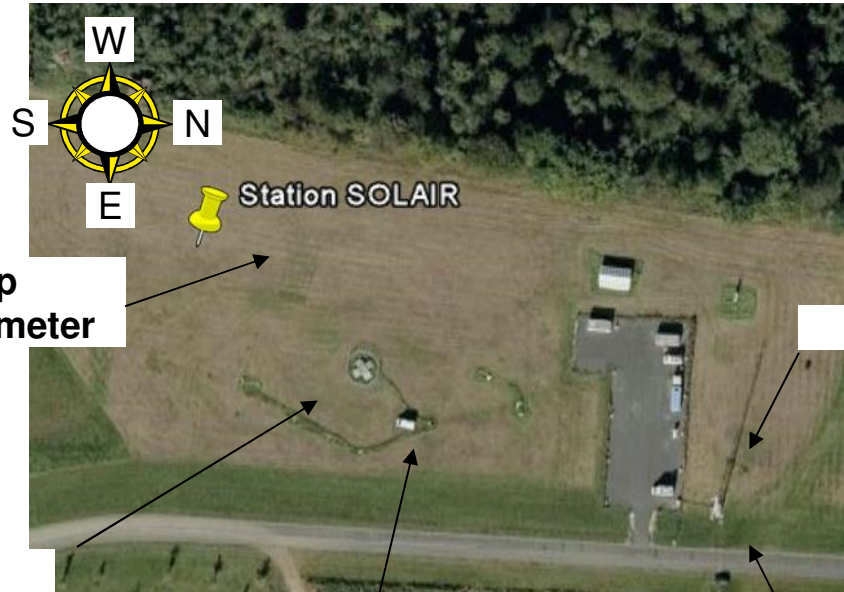


Source: GWEC





**Cup  
Anemometer**



**Wind lidar**



**UHF radar**



**Sonic  
Anemometer**



**Sodar**

## In-situ Sensors

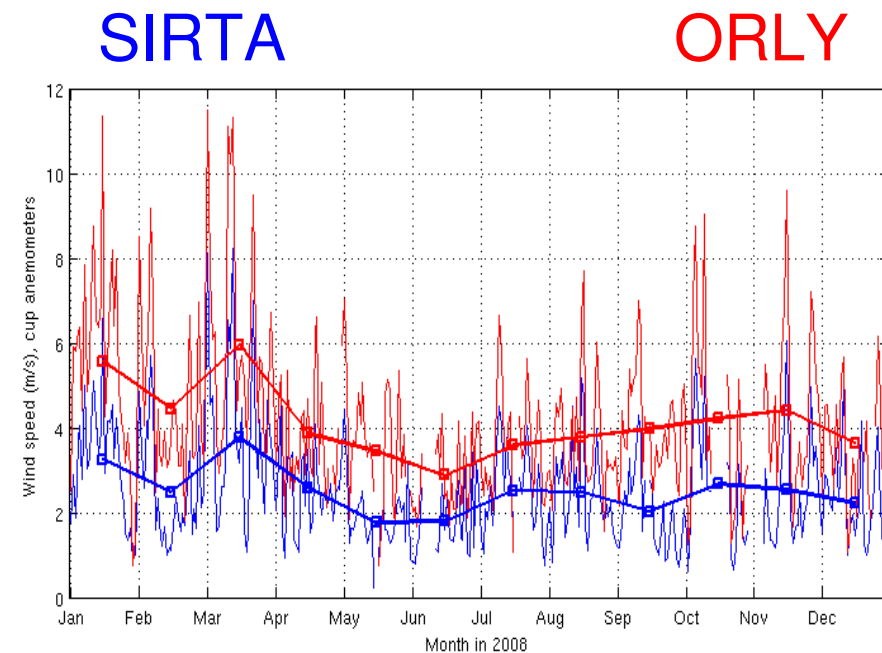
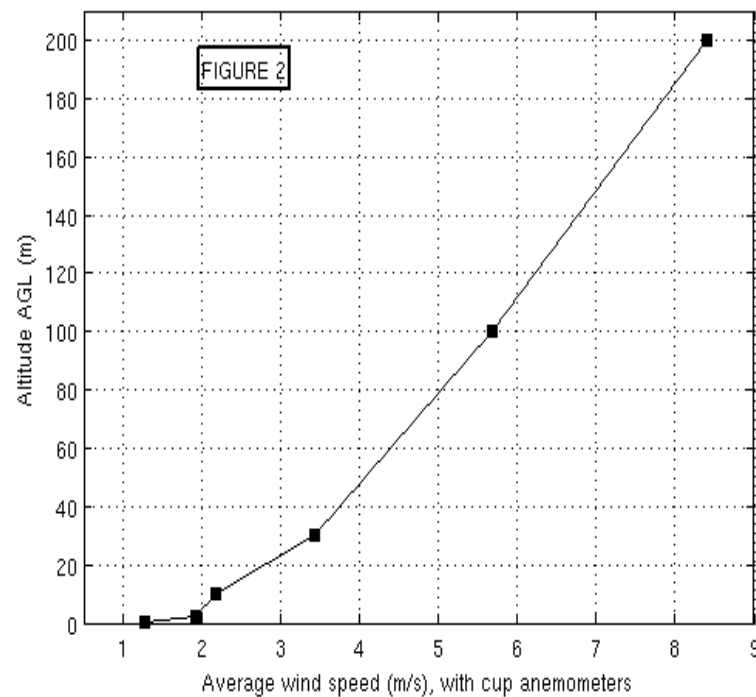
High sensitivity and accuracy,  
fast sampling

## Remote Sensors

Volumic and temporal  
description of the atmosphere

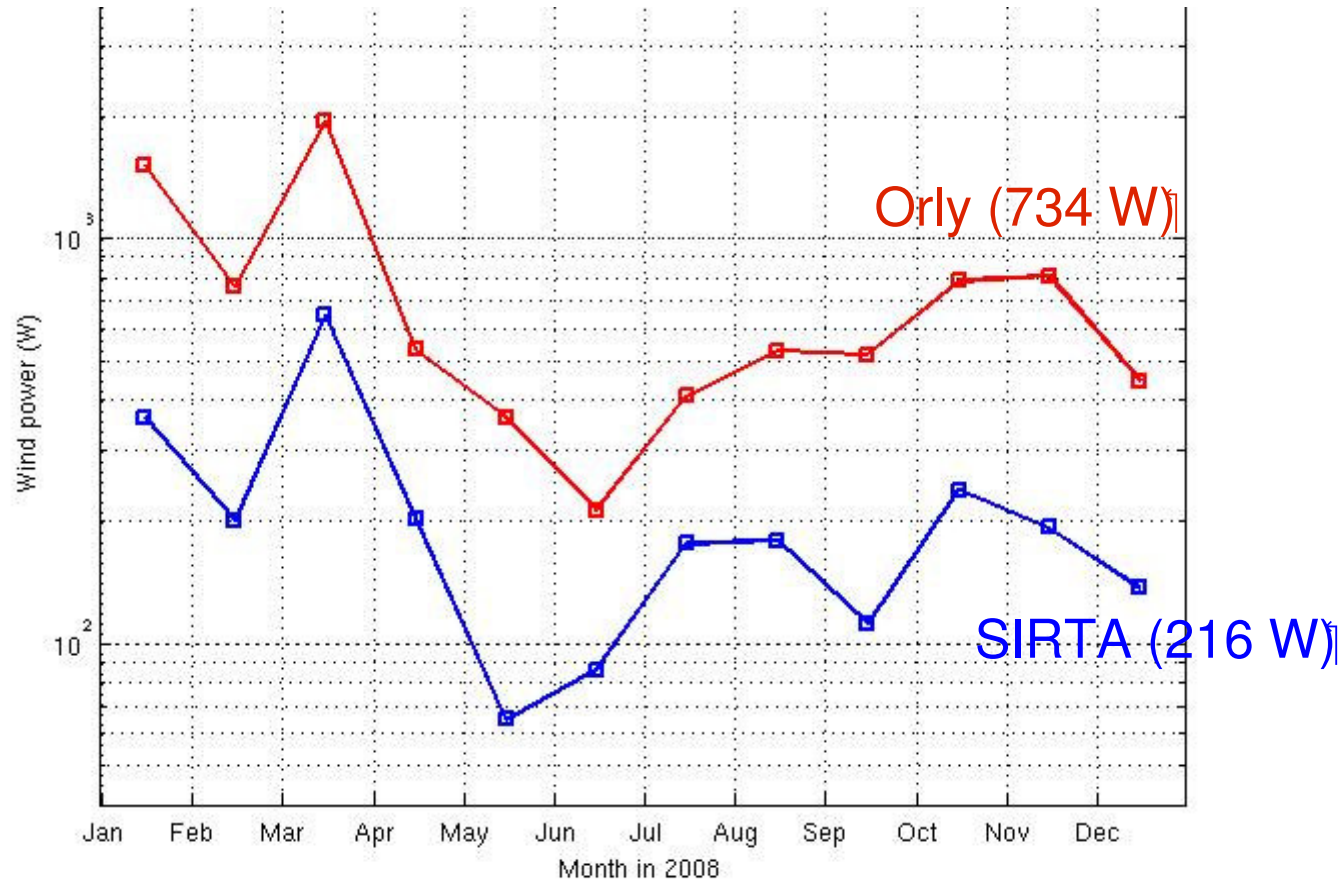
*Wind power production = turbine properties x wind parameters*

- size
- efficiency
- variability
- wind speed
  - altitude
  - surface friction
  - surroundings





## Wind Power at SIRTA & Orly site at 10m altitude



↓	60m altitude	98	kW
	80m altitude	233	kW
	120m altitude	811	kW
	200m altitude	4226	kW

$$\overline{P}_w = \frac{1}{2} \cdot \overline{U}^3 \cdot \bar{\rho} \cdot S \cdot C_p \cdot K_e$$

**Wind strength**

$$\overline{U}(z) = \frac{u_*}{K} \left[ \ln\left(\frac{z}{z_0}\right) - \Psi\left(\frac{z}{L}\right) \right]$$

**Wind variability**

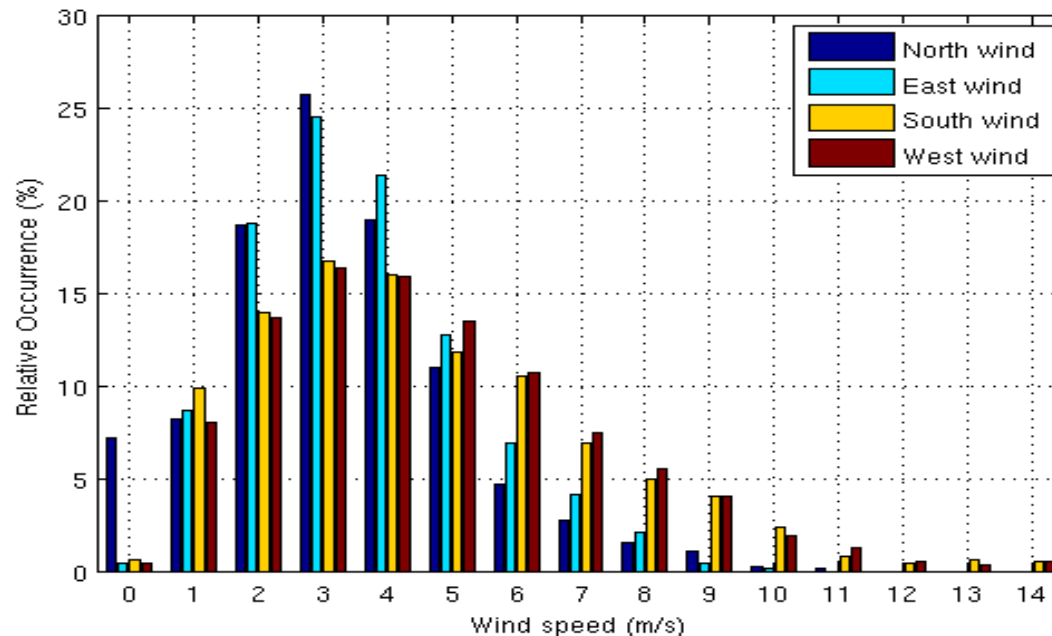
$$K_e = \frac{\overline{U}^3}{U^3}$$

- Increases with height
- Decreases with roughness

- Decreases with height
- Increases with roughness

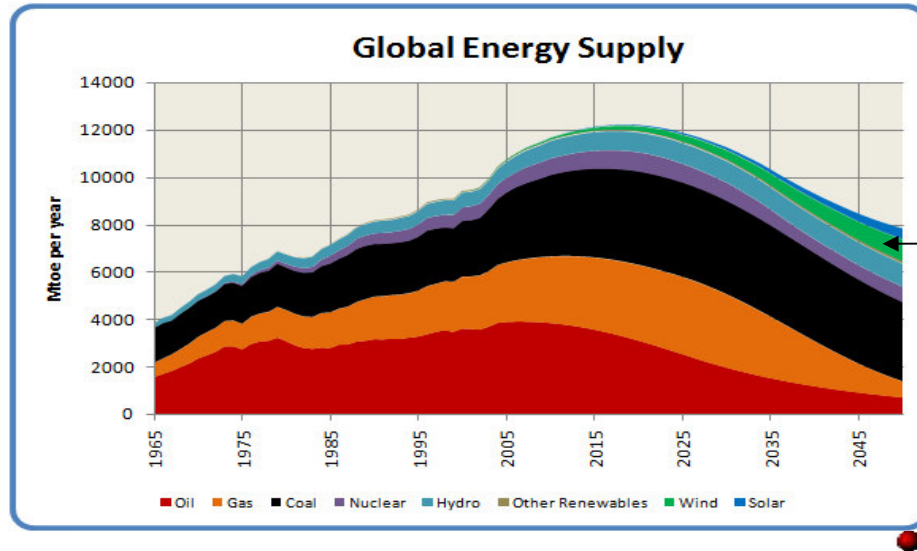
## Wind strength distribution

Distribution of the horizontal wind speed for each direction North/East/South/West over SIRTA site in 2008



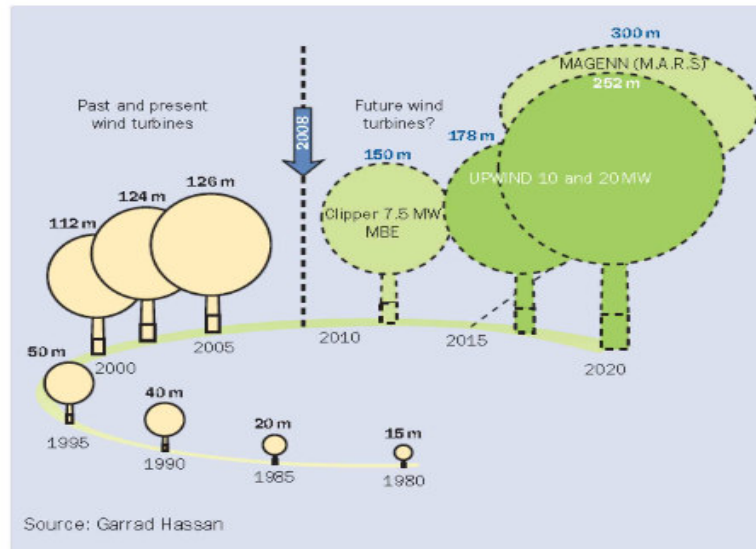
- The higher the better
- But the most spread too
- Strength is dominating over variability

## WIND vision



Vision for the future:

- new generation windmills
- offshore windparks
- increase energy efficiency
- reduce energy consumption





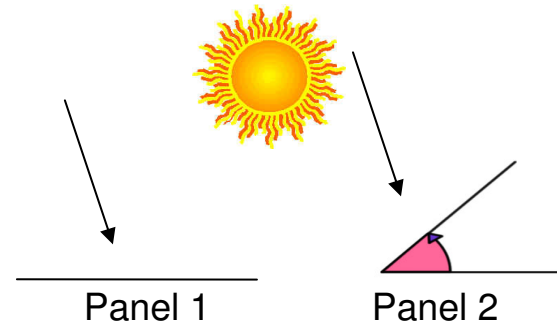
## PV SOLAR ENERGY



## Introduction of experiments

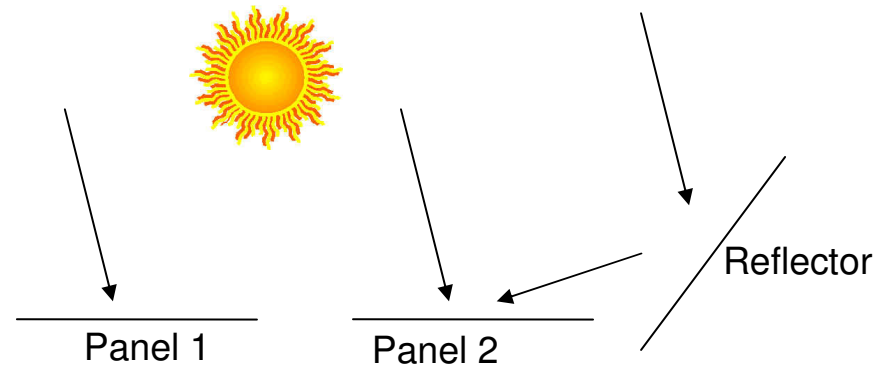
1<sup>st</sup> experiment:

- Panel 1 in horizontal position
- Panel 2 inclined facing the sun



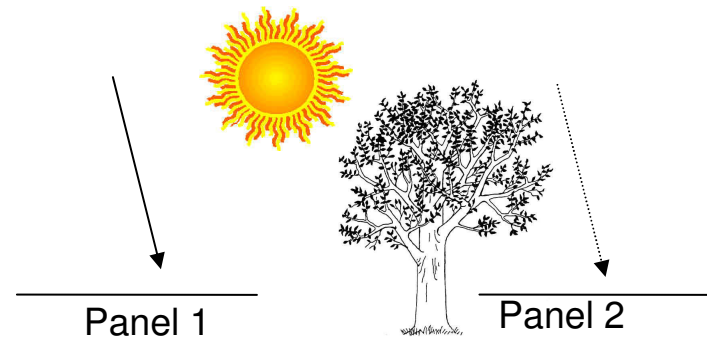
2<sup>nd</sup> experiment:

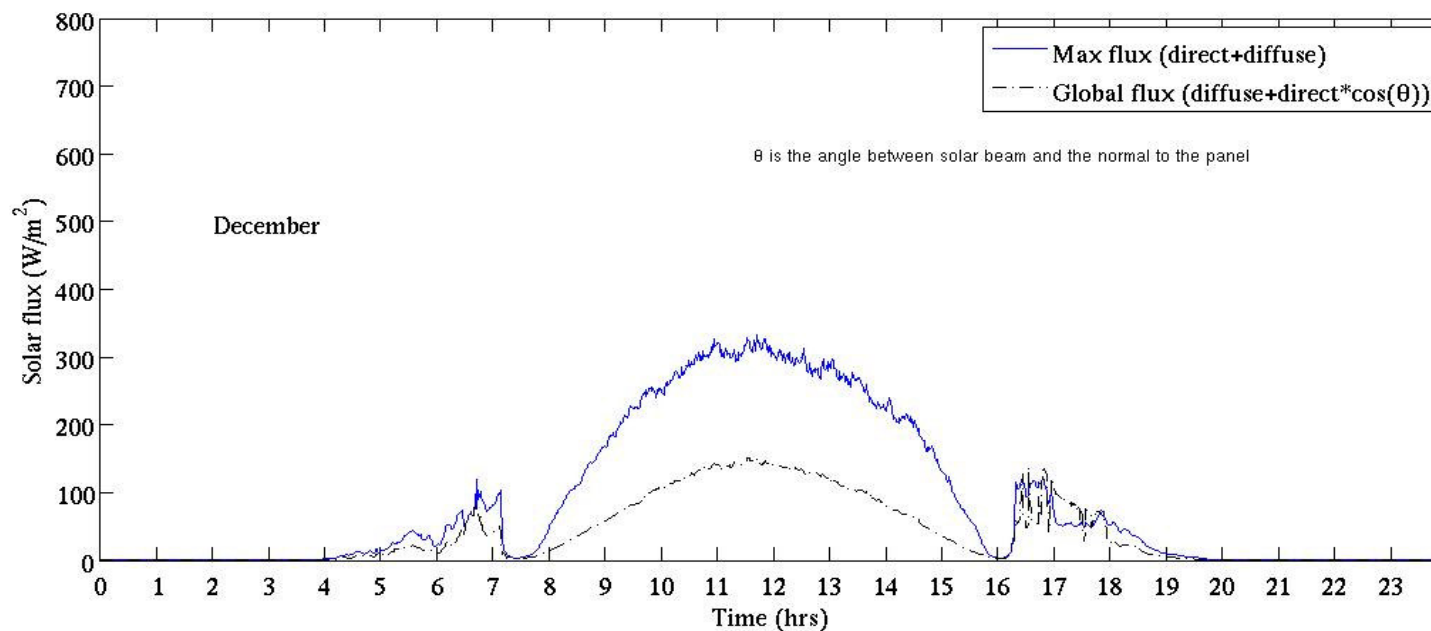
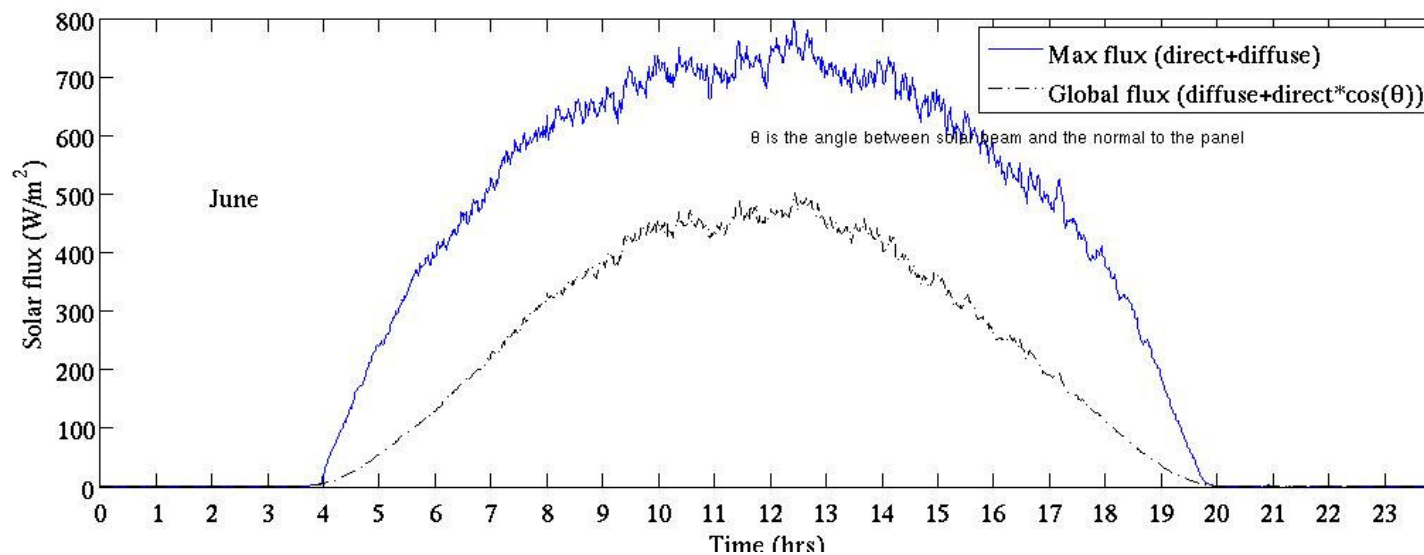
- Panel 1 in horizontal position
- Reflector pointing on panel 2



3<sup>rd</sup> experiment:

- Panel 1 in horizontal position
- Panel 2 in changing shadow







## 1. Method

$$\text{Efficiency} = \text{Power Output}[\text{W/m}^2] / \text{Irradiance}[\text{W/m}^2]$$

-> Power Output = (Voltage \* Current) / Area

-> Irradiance Values from Pyrheliometer



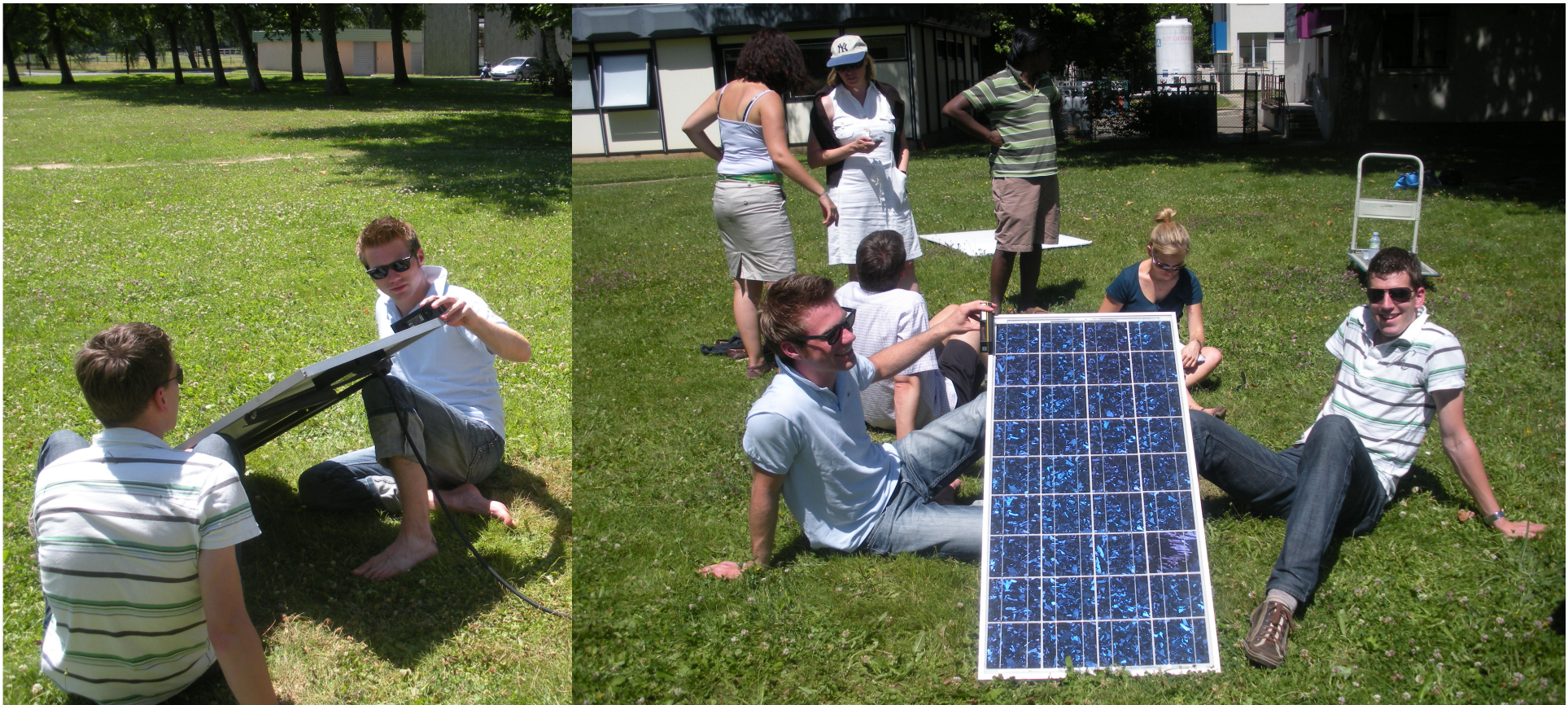
## 2. Calculation

Voltage: 19 V, Current: 4.9 A, Irradiance: 890 W/m<sup>2</sup>

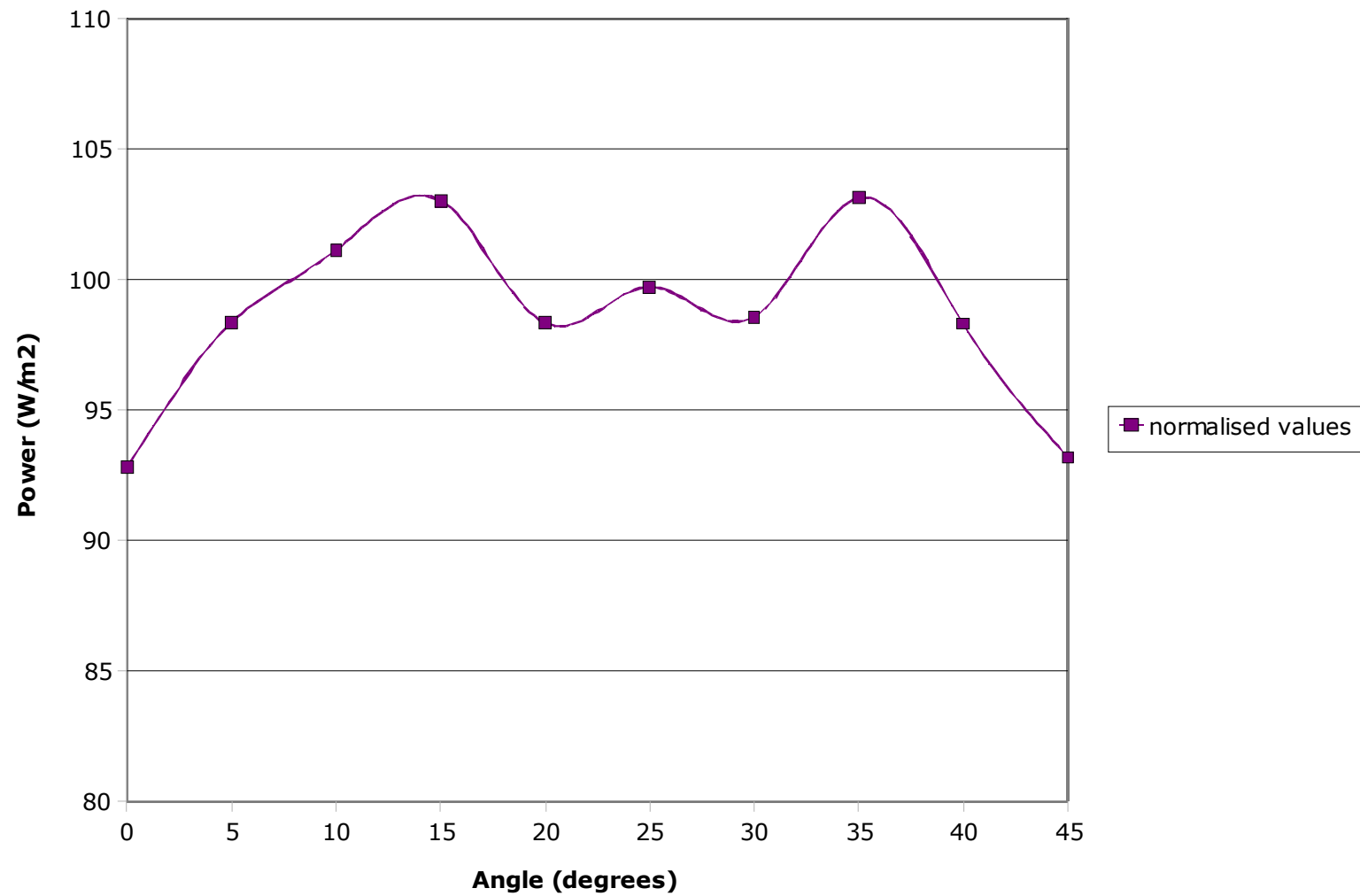
-> equals an efficiency of 18%



- Inclining the solar panel towards the sun to obtain a perpendicular angle renders higher energy output.
- Maximum power output is produced when the solar panel is perpendicular to the sun beam.



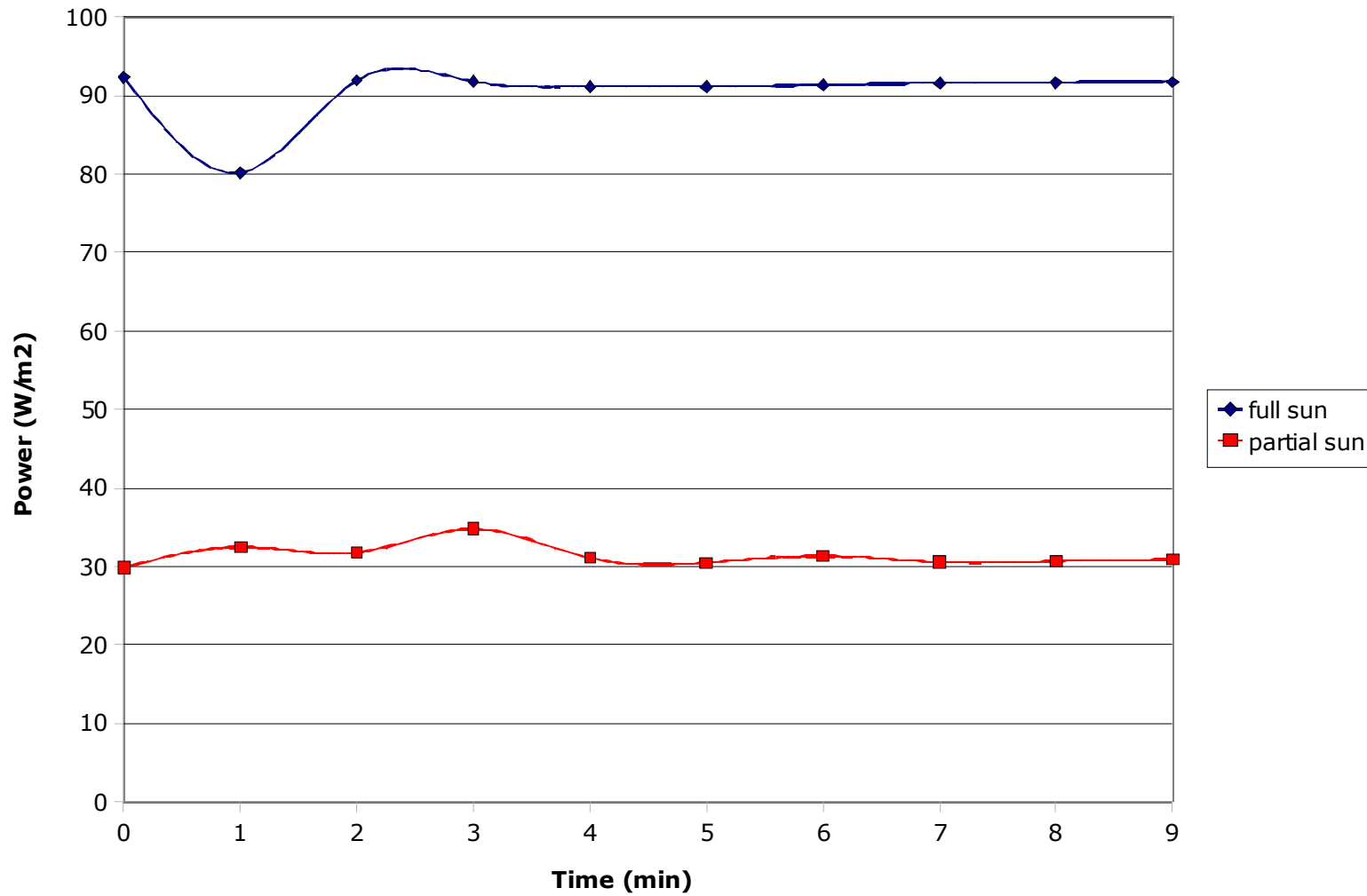
## Variation of Power with angle





- Local albedo influences the energy output produced by solar panels.
  - Diffusion with white board, also influences the power produced.
  - A change in the inclination of the white board also changes the power output and is maximum at a certain angle.
- 
- Max power :  $6.02 \text{ A} * 19.50 \text{ V}$
  - Avg power w/o white board =  $4.9 \text{ A} * 18.7 \text{ V}$

## Variation of sun and partial shade

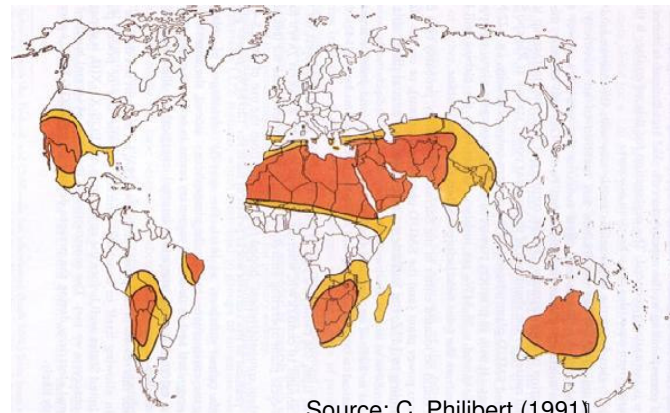


- ✓ Natural parameters:
  - ✓ Season
  - ✓ Weather (clouds etc)
  - ✓ Landscape (geographic location, albedo)
  - ✓ Natural phenomena (volcano etc)
  
- ✓ Other parameters:
  - ✓ Aerosols (manmade)
  - ✓ Angle of panel
  - ✓ Position of panel (relative to the sun)
  - ✓ Shadow
  - ✓ Quality of solar cells (incl. lifetime)
  - ✓ Post-processing of solar energy production (e.g., voltage, transformator, stabiliser, batteries etc)



## SOLAR vision

- New opportunities: Solar cell films etc
- Opportunity for 3<sup>rd</sup> World countries to take a leading role



- New applications for consumers and businesses:
  - All roofing might contain solar elements
  - Personal appliances (e.g. Clothing, watches, too?)
  - Higher energy awareness -> energy use in sync with natural solar production cycle
- How will a country's new energy mix change pricing and (thus) usage??